# Morphological diversity within the genus *Dendrobium* Swartz (Orchidaceae) in Northeast India[a]

Chaya Deori[1]

**Keywords/Mots-clés** : *Dendrobium*, morphological diversity/diversité morphologique, Northeast India/Inde du nord-est, Orchidaceae.

## Abstract

The paper provides a discussion of the genus *Dendrobium* Swartz in Northeast India, including detailed information about the range of diversity in respect to vegetative and floral characteristics. The data is complemented by representative illustrations and photographs.

## Résumé

**Diversité de formes dans le genre *Dendrobium* Swartz (Orchidaceae) dans le nord-est de l'Inde** – L'article propose une discussion des espèces de *Dendrobium* Swartz présentes en Inde du nord-est et fournit une information détaillée sur la diversité des caractères végétatifs et floraux qu'elles présentent. Un ensemble de planches (photographies et dessins) accompagne la discussion.

## Introduction

The family Orchidaceae exhibits an amazingly large species diversity, whereby this variation is found in the size, shape, structure of the vegetative and floral characteristics as well as in the colour and fragrance of the flowers. *Dendrobium* Swartz (1799: 82) is one of the largest genera of

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Orchidaceae, comprising approximately 1450 species (Schuiteman, 2014). The genus shows a wide range of morphological variations corresponding to its wide area of distribution. Indeed, the species of *Dendrobium sensu lato* are to be found from Sri Lanka throughout tropical Asia and the Pacific region, north to Japan, east to Tahiti, and south to New Zealand (Schuiteman, 2014). According to Misra (2007), the genus is represented in India by 116 species. The present study accounts for 96 species from Northeast India (Apang, 2012; Bhatacharjee et al., 2008; Chowdhery, 2009; Deori, 2007; Deori et al., 2008; Deori, et al., 2009, 2009a; Deori, 2014; Hooker, 1890; Kishor, et al., 2014; Kumar & Manilal, 1994; Meitei et al., 2014; Lokho, 2013; Nanda et al., 2014 and Rao, 2007). The genus has been divided into several sections based on morphological studies since its establishment. On the basis of molecular studies, Wood (2006) and Schuiteman (2014) rearranged these sections and included in the genus *Dendrobium* two other genera, *Epigeneium* F.Gagnepain and *Flickingeria* A.D.Hawkes. My own research regarding *Dendrobium* species from northeast India has been based only on morphological characteristics. Therefore, it cannot give any objective conclusions about the proper infrageneric division of the genus. Furthemore, as I consider *Epigeneium* and *Flickingeria* to be morphologically very distinct from *Dendrobium* (see Appendix 1), they are excluded from the present study.

On the basis of the characteristic features of the sections of *Dendrobium* and the results of the study of the species involved, I divide the genus *Dendrobium* as it occurs in northeast India into the following 13 sections:

*Aporum* Blume: *D. acinaciforme, D. anceps, D. curviflorum*, D. keithii, D. mannii, D. spatella, D. nathanielis*, D. terminale*.*

*Bolbidium* Lindley: *D. pachyphyllum*.*

*Breviflores* J.D.Hooker: *D. aduncum, D. bicameratum, D. dantaniense, D. linguella*.*

*Densiflora* Finet: *D. chrysotoxum, D. densiflorum, D. farmeri, D. griffithianum*, D. jenkinsii, D. lindleyi*, D. palpebrae, D. sulcatum, D. thrysiflorum.*

*Dendrobium*: *D. amoenum, D. aphyllum, D. assamicum*, D. bensoniae*, D. brymerianum, D. capillipes*, D. chryseum, D. chrysanthum, D. crepidatum, D. crystallinum*, D. denneanum, D. devonianum, D. dickasonii*, D. findlayanum*, D. falconeri, D. fimbriatum, D. gibsonii, D. gratiosissimum*, D. heterocarpum, D. hookerianum, D. khasianum, D. lituiflorum, D. macrostachyum*, D. moniliforme*,*

*D. moschatum, D. nobile, D. ochreatum, D. parishii*, D. pendulum*, D. polyanthum, D. pulchellum, D. ruckeri, D. tortile, D. transparens, D. ×vexabile*, D. wardianum.*

*Distichophyllae* J.D.Hooker: *D. revolutum*.*

*Formosae* (Bentham & J.D.Hooker) J.D.Hooker: *D. arunachalense, D. bellatulum, D. cariniferum*, D. draconis, D. formosum, D. infundibulum, D. jaintianum, D. longicornu, D. tamenglongense*, D. wattii, D. williamsonii.*

*Grastidium* (Blume) Blume: *D. salaccense.*

*Pedilonum* (Blume) Blume: *D. cumulatum, D. herbaceum*, D. metrium, D. parcum, D. rhodocentrum*, D. versicolor*.*

*Rhopalanthe* Schlechter: *D. angulatum.*

*Stachyobium* Lindley: *D. darjeelingense*, D. delacourii, D. denudans, D. eriiflorum, D. miserum*, D. monticola*, D. numaldeorii, D. nareshbahadurii*, D. peguanum, D. porphyrochilum, D. pycnostachyum*, D. sessanicum*, D. sinominutiflorum*, D. strongylanthum*.*

*Strongyle* Lindley & J.Paxton: *D. kentrophyllum*, D. parciflorum.*

*Stuposa* Kraenzlin: *D. stuposum, D. praecinctum.*

In doing so, I follow Hooker (1890), Lindley (1859), Pradhan (1979), Seidenfaden (1985), Pearce & Cribb (2002), Wood (2006), and Schuiteman (2014).

The present article deals with the vast range of diversity of the vegetative and floral characteristics of the various species (Fig. 1-5). Identification keys to the 13 sections and the species therein are provided. *Dendrobium tamenglongense, D. sessanicum* and *D. versicolor* have been excluded as the pertinent literature did not yield satisfactory information regarding these taxa.

The present study is based on the examination of specimens that were wild collected and cultivated at the National Orchidarium in Shillong as well as on herbarium from the Central National Herbarium in Kolkata (CAL), the Regional Herbarium in Shillong (ASSAM), the herbarium of the Botanical Survey of India in Itanagar (ARUN), the herbarium of the Botanical Survey of India, Sikkim Himalayan Circle (BSHC), the Orchid Herbarium at Tipi, Bhalukpung, Arunachal Pradesh (OHT), and digital images of herbarium specimens from Kew (K). For those species of which no living material could be collected (marked with a * in the above list), the data was extrapolated from literature and herbarium materials.

## Morphological Diversity

The morphological characters allowing the identification of the different species are as follows.

### Habit

Sympodial with pseudobulbs or elongated stems (Plates 1 & 2).

### Roots

Generally, the roots of *Dendrobium* develop below the pseudobulb. However, in plants belonging to the sections *Dendrobium*, *Pedilonum*, *Stuposa* and *Rhopalanthe*, roots are also generated from nodes, allowing the development of adventive growths that eventually drop off. The species belonging to the sections *Dendrobium*, *Densiflora*, *Grastridium* and *Formosae* generate fasciculate, thick roots that are covered by a shiny, silver-grey velamen. All other *Dendrobium* species occurring in northeast India generate slender to filiform roots. The thickness of the roots varies from 0.1 to 4 mm in diameter: in sections *Aporum*, *Breviflores*, *Strongyle* and *Stuposa* the roots are 0.1 to 1.5 mm thick, in sections *Dendrobium*, *Densiflora*, *Formosae* and *Pedilonum* 0.5 to 3 mm thick, in section *Grastidium* 3 to 4 mm thick, and in the sections *Stachyobium* and *Rhopalanthe* they vary between 0.9 and 1.3 mm in diameter. Roots of plants of the sections *Bolbidium* and *Distichophyllae* could not be observed.

### Pseudobulbs/stems

The size of the pseudobulbs or stems varies from a few centimetres to more than a meter. The stems of the species of sections *Aporum* (Fig. 2A, G), *Strongyle* (Fig. 2R) and *Grastridium* (Fig. 2E) are wiry without any fleshy internodes. They generate sheathed leaves all along the stem. In the other sections, some of the internodes are fleshy and swollen. The species of section *Densiflora* (Fig. 2B, H, K) generally generate pseudobulbs that are stout, fusiform, clavate, compressed, quadrangular, tough, fleshy, and swollen. These plants generate few terminal leaves. Section *Distichophyllae* is characterized by stiff leafy stems. Section *Dendrobium* is characterized by short, long, pendulous or erect stems with few to many nodes. Internodes are swollen or beaded in few species of this section viz. *D. falconeri*, *D. wardianum*, *D. pendulum* and *D. findlayanum* (Fig. 2I, L). In *Rhopalanthe* (Fig. 2O) with a single species from northeast India, the stem is wiry and thin except near the base where it shows some swollen internodes.

*Breviflores* (Fig. 2D) is characterized by slender stems that are swollen towards the apex. The plants of section *Stuposa* (Fig. 1E) are characterized by slender and branching stems (*D. praecinctum*). *Pedilonum* is characterized by slender stem, leafy towards growing end in *D. cumulatum* and caespitose, sub-fusiform, branched stems in *D. herbaceum*, *D. parcum* (Fig. 2P). *Formosae* is characterized by small to large, robust (Fig. 1L, 2M, *D. bellatulum*) or slender (*D. wattii*, *D. longicornu*) pseudobulbs. *Bolbidium* (Fig. 2Q) with a single species from the region has short stem with swollen internodes. Section *Stachyobium* has small globose, cylindric-conical (Fig. 1D, 2N) to long, slender, fusiform stems, tapering towards the apex (Fig. 1G, 2J, *D. eriiflorum* etc.).

**Leaves**

The leaves of the *Dendrobium* species in the region are glabrous or sparsely hirsute. There can be one to many leaves that are either generated apically (on top of the pseudobulb) or arranged distichously along the stem. The leaves are green and their length varies from 2.5 to 18 cm. The leaves are laterally compressed or flattened in section *Aporum* (Fig. 2A, G), linear-lanceolate, elliptic, oblong or ovate in sections *Breviflores*, *Distichophyllae*, *Grastidium*, *Stuposa*, *Pedilonum* and *Dendrobium*, or dorso-ventrally compressed (section *Rhopalanthe*), terete (section *Strongyle*). They are papery or coriaceous, many veined, and their apex can be oblique or not, usually bi-lobed or emarginated, acute or obtuse. There are 1 to 4 ovate to oblong, acute to obtuse, entire, glabrous or hirsute sheaths. Two species of *Densiflora* (*D. jenkinsii* and *D. lindleyi*) have single leaves generated apically on the pseudobulb. Section *Bolbidium* has two leaves generated apically on the pseudobulb whereas the other sections of the region have more than two leaves. The leaf sheaths of the section *Formosae* (Fig. 2M, S) are covered with dark brown or blackish hairs, those of the remaining sections are glabrous.

**Inflorescence**

The inflorescence of north-eastern Indian *Dendrobium* is a raceme. It is either generated axillary or terminal, and arises from short or long peduncles borne on nodes of leafy or leafless stems. The rachis is long or short, slender, thick or thin, greenish-yellowish. The peduncles are slender and sheathed. In section *Bolbidium* the inflorescence is a single-flowered raceme. In section *Densiflora* (with the exception of *D. jenkinsii*) the

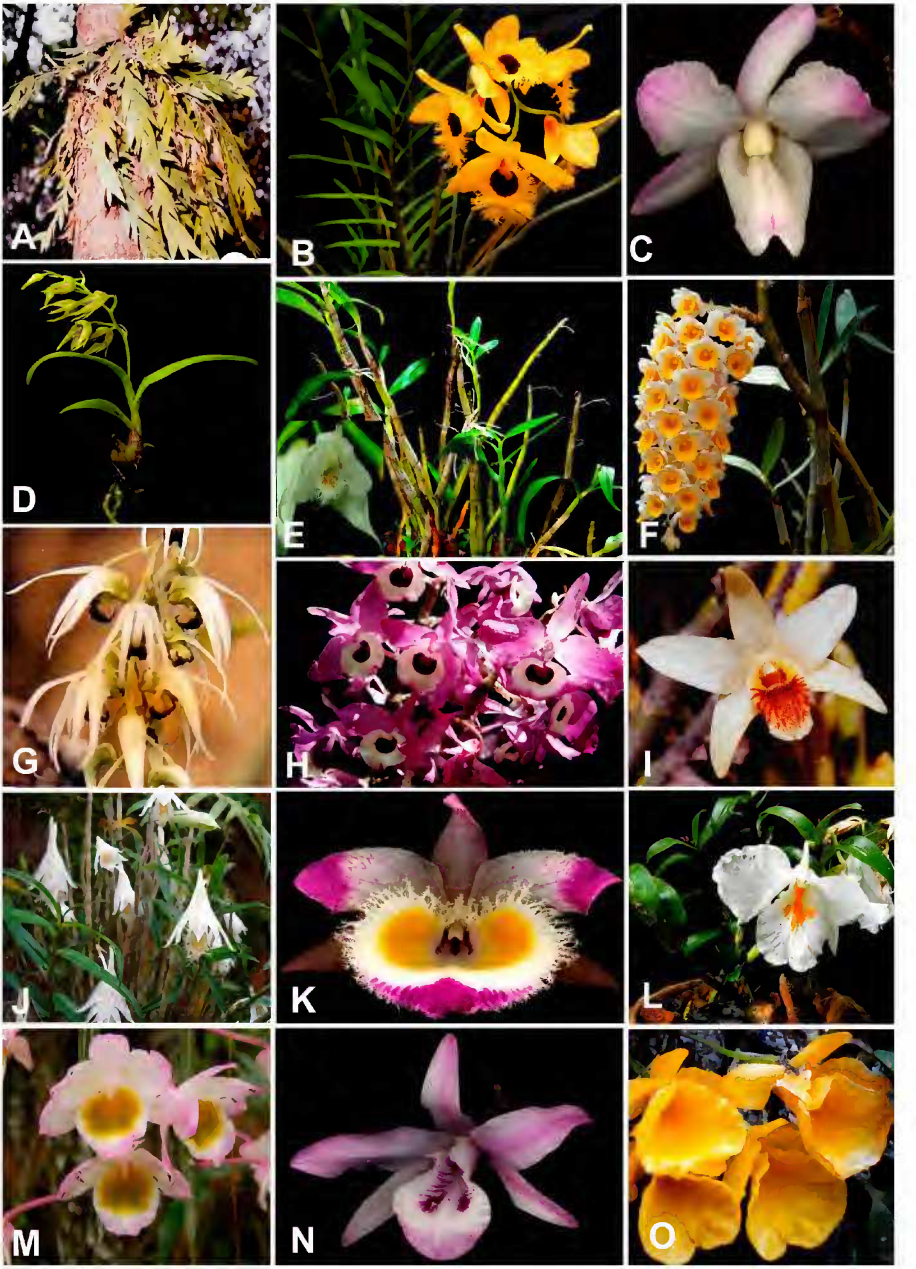


**Fig. 1**
(caption on the opposite page)

inflorescence is mostly pendent and generated from the upper nodes of stems. The species of section *Formosae* usually generate their flowers near the apex of the stem, most of them with very short scape of one to two flowers. Section *Distichophyllae* has a lateral inflorescence that stands vertically on the stem. In sections *Pedilonum* (Fig. 1C), *Breviflores* (Fig. 2C, D) and *Stuposa* (Fig. 1E, *D. praecinctum*), the inflorescences most often bear one or few flowers, and then are fascicled. The species of section *Dendrobium* have a few to many flowered raceme borne on nodes of leafy or leafless stems. In section *Stachyobium*, the inflorescence is sub-terminal or lateral, with several to many small flowers on a long scape and rachis. The inflorescence in sections *Aporum* (Fig. 1A) and *Strongyle* (Fig. 2R) is a terminal or lateral raceme with one or few flowers. The species of the sections *Grastidium* (Fig. 2E) and *Rhopalanthe* (Fig. 2O) have 2 to 3 flowers on a lateral short-lived raceme generated from very short peduncles borne on nodes of leafless stems.

**Floral bracts**

All the *Dendrobium* species of northeast India have floral bracts that vary in shape, size, texture and are taxonomically significant. The floral bracts may be ovate, oblong acute, obtuse, acuminate, entire, glabrous or hirsute, and transparent. All the sections of *Dendrobium* found in the region, except for the section *Formosae*, have glabrous floral bracts. In section *Formosae* the floral bracts are hirsute.

**Flowers**

The pedicellate ovary may be short or long, gently curved, greenish, yellowish and is often ridged. The flowers of *Dendrobium* of north-eastern India are very showy, resupinate, short or long-lived. They vary in size, shape and colour. The flowers of some of the species are very sweetly scented. The sizes of the flowers vary from 10 to 80 mm across. The species belonging to the sections *Aporum* (Fig. 3E, K), *Bolbidium* (Fig. 3V), *Breviflores* (Fig. 3M), *Grastidium* (Fig. 3U), *Rhopalanthe* (Fig. 3W), *Stachyobium* (Fig. 3S, T), *Strongyle*

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**Fig. 1** (opposite page)
**A.** *Dendrobium anceps*. **B.** *D. khasianum*. **C.** *D. cumulatum*. **D.** *D. porphyrochilum*.
**E.** *D. stuposum*. **F.** *D. thyrsiflorum*. **G.** *D. denudans*. **H.** *D. lituiflorum*.
**I.** *D. heterocarpum*. **J.** *D. arunachalense*. **K.** *D. devonianum*. **L.** *D. formosum*.
**M.** *D. crepidatum*. **N.** *D. transparens*. **O.** *D. jenkinsii*.

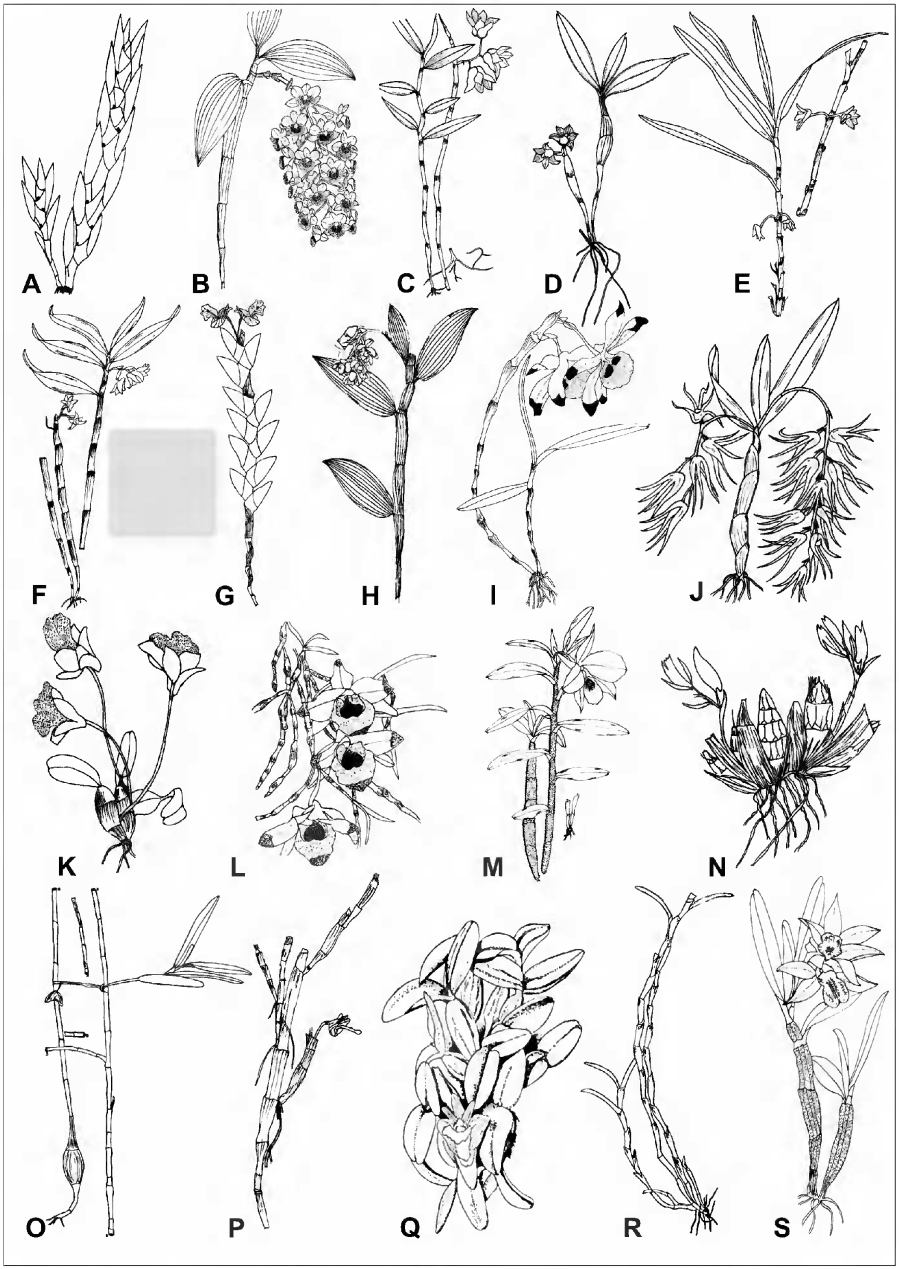


**Fig. 2: Habit of some *Dendrobium***

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(Fig. 3N) and *Stuposa* (Fig. 3F) have flowers smaller in size as compared to flowers in sections *Pedilonum* (Fig. 3Q, R, X), *Densiflora* (Fig. 3G, L), *Distichophyllae, Dendrobium* (Fig. 3A, B, C, D, H, I) and *Formosae* (Fig. 3J, O, P). The flowers are mostly yellow in sections *Densiflora* (Fig. 1O, 3G) and *Dendrobium* (Fig. 1B), mostly white or creamish-yellow in section *Formosae* (Fig. 1L) and creamish to greenish white with pinkish purple shades in the remaining sections.

**Sepals**

Dorsal sepals are ovate acute or obtuse (Fig. 4A, C, O), concave, oblong-elliptic (Fig. 4B, K), oblong obtuse (Fig. 4D, E, F, L, N, P), oblong-lanceolate, acute or obtuse, acuminate (Fig. 4H, I, S), linear lanceolate or lanceolate acute or acuminate (Fig. 4G, J, M, Q, R). The apex may be apiculate (*D. cariniferum, D. denneanum, D. ochreatum*), emarginated or retuse (*D. fimbriatum, D. khasianum, D. pulchellum*), margin entire, few to many nerved, lateral nerves branched or not. Some of the species in sections *Formosae* (*D. arunachalense, D. formosum,* etc.), *Dendrobium* (*D. ochreatum*), *Pedilonum* (*D. parcum*) have keels on the dorsal side of the dorsal sepal.

Lateral sepals are ovate-falcate, obtuse, acuminate (Fig. 4A, C), triangular acute or acuminate (Fig. 4B, H, I, J), ovate-lanceolate acute (Fig. 4O), ovate acute or obtuse (Fig. 4D, E, K, M, P), oblong or oblong-lanceolate acute, subacute, obtuse (Fig. 4F, L, N), lanceolate acute or acuminate (Fig. 4G, Q, R) or falcate acute (Fig. 4S). They are few to many nerved. The mentum formed by the fusion of the lateral sepals to the foot of the column is often spur like, conical, saccate and rounded. Size of mentum may vary from species to species. The mentum in section *Formosae* is long, conical, funnel shaped, straight or incurved (Fig. 3J) except in *D. bellatulum* where it is short. In section *Pedilonum* the species have rounded mentum (Fig. 3Q, X) except in *D. cumulatum* and *D. rhodocentrum* which have a long mentum. In sections *Aporum* (Fig. 3E, K), *Bolbidium* (Fig. 3V), *Breviflores* (Fig. 3M),

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**Fig. 2** (opposite page)
**A**. *D. anceps*. **B**. *D. densiflorum*. **C**. *D. aduncum*. **D**. *D. bicameratum*. **E**. *D. salaccense*. **F**. *D. stuposum*. **G**. *D. mannii*. **H**. *D. sulcatum*. **I**. *D. wardianum*. **J**. *D. numaldeorii*. **K**. *D. jenkinsii*. **L**. *D. falconeri*. **M**. *D. infundibulum*. **N**. *D. peguanum*. **O**. *D. angulatum*. **P**. *D. parcum*. **Q**. *D. pachyphyllum* (after Seidenfaden, 1985). **R**. *D. parciflorum*. **S**. *D. williamsonii*.

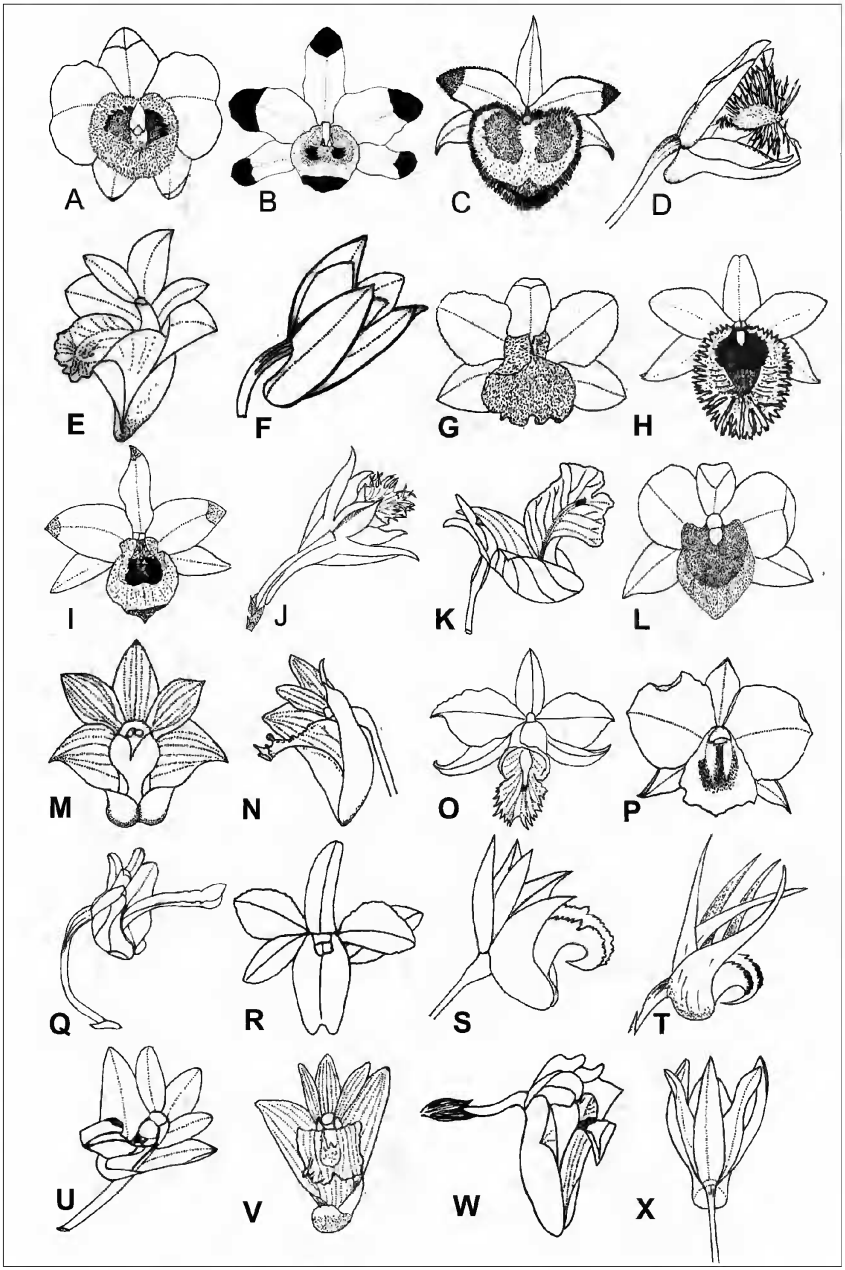


**Fig. 3: Morphological range of *Dendrobium* flowers**

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*Densiflora*, *Dendrobium* (Fig. 3D), *Distichophyllae*, *Grastidium* (Fig. 3U), *Rhopalanthe* (Fig. 3W), *Stachyobium* (Fig. 3S, T), *Strongyle* (Fig. 3N) and *Stuposa* (Fig. 3F) the mentums are saccate, rounded in shape.

**Petals**

They are linear or broadly lanceolate, acute or obtuse (Fig. 4A, C, H, Q), elliptic obtuse or acute (Fig. 4B), elliptic-ovate, obtuse, acute (Fig. 4E, F, G, J), suborbicular to orbicular, elliptic apiculate (Fig. 4D, K), rhombate acute (Fig. 4I), oblong obtuse (Fig. 4L, O) spathulate obtuse (Fig. 4P), obovate obtuse (Fig. 4N), oblong-lanceolate acute, obtuse (Fig. 4M, R, S). They are single to many nerved, lateral nerves branched or not, finely reticulate, free from the dorsal sepal, margin entire or erose towards apex, undulate, glabrous. The size of the two petals may be similar or not.

**Lip**

The lip is attached to the column foot. In sections *Aporum*, *Bolbidium*, *Dendrobium* (except *D. assamicum*, *D. heterocarpum*, *D. ruckeri*), *Densiflora*, *Grastidium*, *Pedilonum* (except *D. metrium* and *D. herbaceum*) and *Strongyle* the lip is simple, with variable shapes and margins. It may be orbicular, suborbicular to wedged shaped, rhombic, pouch like, convolute, cordate, subquadrate, transversely obcordate, oblong, triangular, oblanceolate; margin revolute, involute, undulate, entire, erose, dentate, serrate, fimbriate, ciliate, or ciliolate; surface pubescent or not. Species belonging to sections *Breviflores* (except *D. aduncum* and *D. linguella*), *Distichophyllae*, *Formosae* (except *D. jaintianum*), *Rhopalanthe*, *Stachyobium*, *Stuposa*, *Pedilonum* (except *D. cumulatum*, *D. parcum* and *D. rhodocentrum*) are distintly 3-lobed. The side lobes may be rounded, orbicular (Fig. 4I), triangular (Fig. 4J) or ovate; hispid or pubescent; entire or fimbriate (Fig. 4C), deeply irregularly inciso-serrate (Fig. 4R), laciniate (Fig. 4Q),

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**Fig. 3** (opposite page)
**A**. *D. chrysanthum*. **B**. *D. wardianum*. **C**. *D. devonianum*. **D**. *D. brymerianum*. **E**. *D. anceps*. **F**. *D. praecinctum*. **G**. *D. densiflorum*. **H**. *D. khasianum*. **I**. *D. falconeri*. **J**. *D. arunachalense*. **K**. *D. mannii*. **L**. *D. palpabrae*. **M**. *D. aduncum*. **N**. *D. kentrophyllum* (after Seidenfaden, 1985). **O**. *D. wattii*. **P**. *D. infundibulum*. **Q**. *D. parcum*. **R**. *D. cumulatum*. **S**. *D. eriiflorum*. **T**. *D. denudans*. **U**. *D. salaccense*. **V**. *D. pachyphyllum* (after Seidenfaden, 1985). **W**. *D. angulatum*. **X**. *D. metrium*.

crenate or erose (Fig. 4I), erect acuminate, acute (Fig. 4B), or obtuse. Midlobes are transversely quadrate and incurved, ovate and recurved (Fig. 3S, T), crisped, rounded (Fig. 4S), or ovate-triangular with an acute or acuminate (Fig. 4H, Q), emarginated or retuse apex (Fig. 4E, N, O, P). Disc ridged or lamellate, 2 maroon blotched or not, yellow blotched or not on either sides of the disc, glabrous or pubescent, smooth or verrucose (Fig. 4Q). The colour of the lips are creamish or greenish-yellow, yellow, orange, reddish, whitish, pinkish with one or two blotches at the centre. Maroon or dark purple blotches are present in section *Dendrobium* (Fig. 1B, H) and yellow, orange or greenish yellow blotches are present in sections *Dendrobium* (Fig. 1I, K, M) and *Densiflora* (Fig. 1F,O). Lip of *D. bicameratum, D. dickasoni, D. porphyrochilum* (Fig. 1D) and *D. praecinctum* are orange, reddish. Orange colour patches are observed in section *Formosae* (Fig. 1J, L).

**Column, Anther and Pollinia**

Often the base of the column forms a ventral extension called the column foot to which the lateral sepals are attached to form a mentum. The stigma is three-lobed whereby the two lateral lobes are fertile, while the posterior lobe is absent or modified. The rostellum is recurved, small, transversely lamellate, narrow or wide. There are two stelidia, acute (Fig. $5C_1$, $E_1$, $G_1$, $L_1$), obtuse (Fig. $5A_1$, $F_1$, $J_1$, $K_1$) or toothed (Fig. $5D_1$, $I_1$), small, rounded, broad and flat, projected forwards and upwards; attachment elongate, mostly acute (Fig. $5C_1$, $E_1$, $G_1$, $H_1$, $L_1$), attached to the anther or operculum. The anther is basically most often two chambered, oblong, bilobed (Fig. $5B_2$), rounded, emarginated or retuse (Fig. $5C_2$, $D_2$, $E_2$, $F_2$, $J_2$, $L_2$) at the apex, glabrous or papillous (Fig. $5B_2$, $G_2$), purplish, yellow, or white; anther cap entire (Fig. $5F_2$, $H_2$), erose (Fig. $5G_2$, $K_2$), or dentate, hairy, or wooly (Fig. $5D_2$). There are four pollinia in two pairs. They may be oblong

**Fig. 4** (opposite page)
**A**. *D. mannii*. **B**. *D. bicameratum*. **C**. *D. stuposum*. **D**. *D. densiflorum*. **E**. *D. jenkinsii*. **F**. *D. wardianum*. **G**. *D. falconeri*. **H**. *D. aduncum*. **I**. *D. arunachalense*. **J**. *D. formosum*. **K**. *D. chrysanthum*. **L**. *D. brymerianum*. **M**. *D. angulatum*. **N**. *D. cumulatum*. **O**. *D. salaccense*. **P**. *D. parcum*. **Q**. *D. numaldeorii*. **R**. *D. eriiflorum*. **S**. *D. peguanum*. **T**. Lip of *D. pachyphyllum* (after Seidenfaden, 1985). **U**. Lip of *D. kentrophyllum* (after Seidenfaden, 1985).

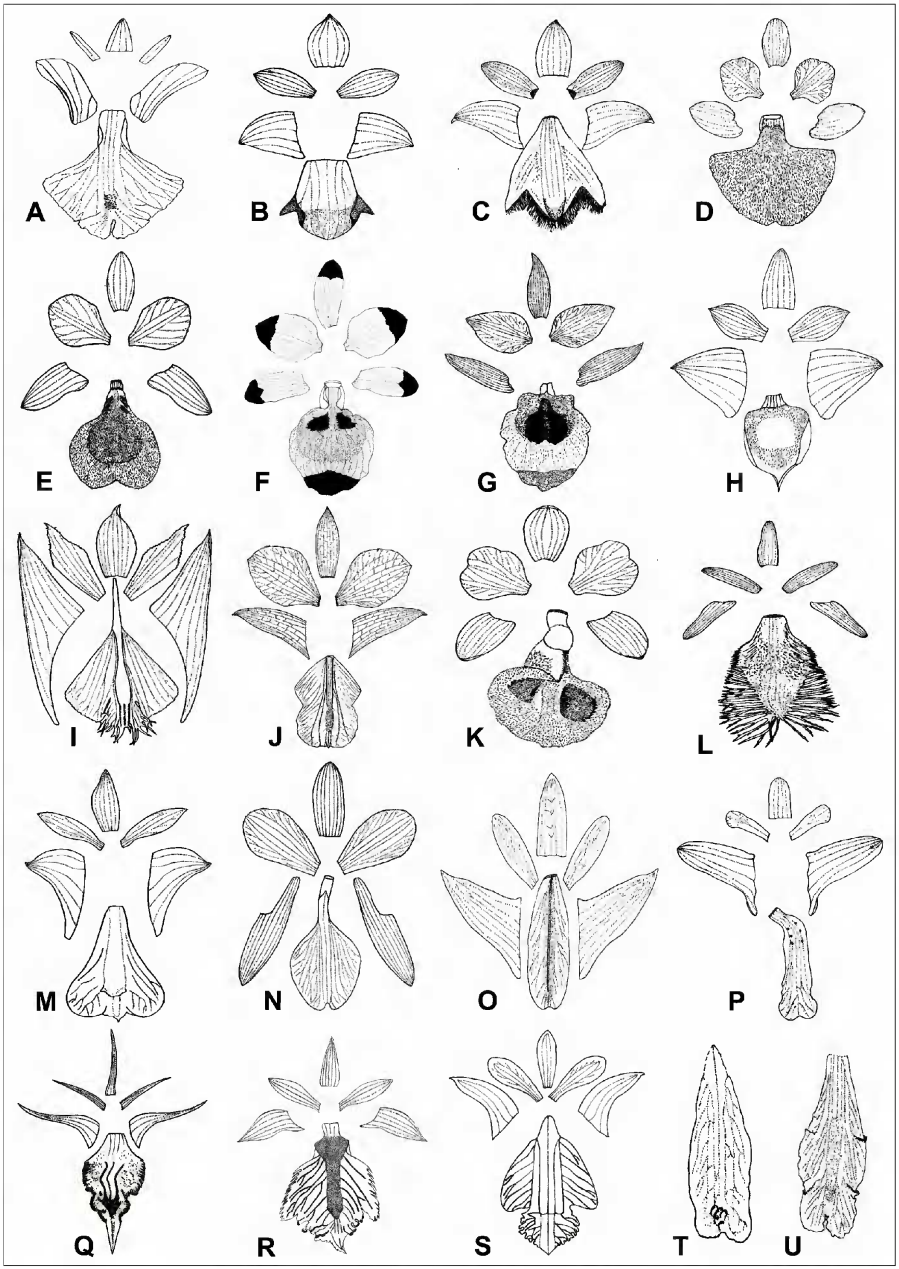


**Fig. 4: Morphological variation of floral perigone of *Dendrobium***
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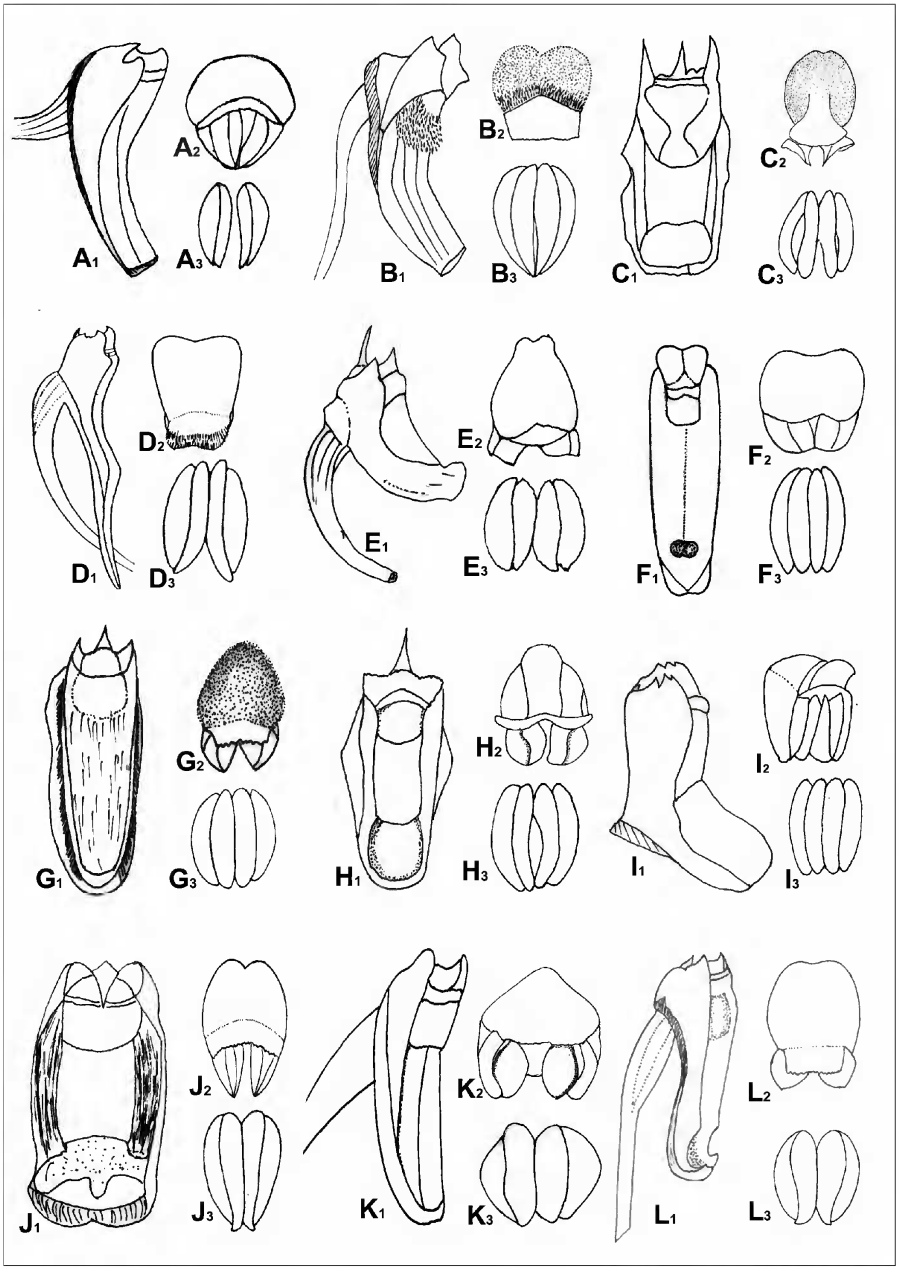


**Fig. 5: Morphological variation of column, anther and pollinia**

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(Fig. 5$C_3$, $F_3$, $H_3$, $I_3$) or ellipsoid (Fig. 5$A_3$, $D_3$, $E_3$, $G_3$, $J_3$, $L_3$), usually sub-equal, edges may be obtuse or sub-acute. They are mostly yellow and few species are pale yellow (Fig. 5$B_3$, $G_3$, $K_3$).

**Capsule and seeds**

The capsules are stalked. It has been observed that species of section *Dendrobium* bear medium to larger fruits while in sections *Aporum*, *Breviflores*, *Stuposa* and *Stachyobium* fruits are of smaller size. They are green to reddish green, glabrous, elongate, ovoid or sub-ovoid, and ridged. However, the fruits of sections *Bolbidium*, *Densiflora*, *Distichophyllae*, *Grastidium*, *Pedilonum*, *Rhopalanthe* and *Strongyle* could not be observed.

## Key to the sections

1a. Small plants characterized by short stems with a single internode; inflorescence appearing between the two leaves and bearing a single flower .....*Bolbidium*

1b. Plants not of this combination.....2

2a. Stems often wiry, internodes never fleshy or swollen.....3

2b. Stems terete, with at least some of the internodes fleshy and swollen.....5

3a.Stems slender, long. Leaves flat and thin, linear lanceolate, dorsiventral or grass like; inflorescences lateral in pairs from short peduncles borne on nodes of leafy stems.....*Grastidium*

3b. Stems wiry; leaves, thick and fleshy, cylindric, subcylindric or laterally compressed.....4

4a.Upper part of stem laterally compressed, basal part terete and smooth; leaves equitant, compressed.....*Aporum*

4b. Stems erect or pendulous; leaves, cylindric, subcylindric, terete..... .....*Strongyle*

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**Fig. 5** (opposite page)

**$A_1$-$A_3$.** *D. anceps.* **$B_1$-$B_3$.** *D. aduncum.* **$C_1$-$C_3$.** *D. densiflorum.* **$D_1$-$D_3$.** *D. arunachalense.* **$E_1$-$E_3$.** *D. parcum.* **$F_1$-$F_3$.** *D. angulatum.* **$G_1$-$G_3$.** *D. metrium.* **$H_1$-$H_3$.** *D. chrysanthum.* **$I_1$-$I_3$.** *D. peguanum.* **$J_1$-$J_3$.** *D. moschatum.* **$K_1$-$K_3$.** *D. bicameratum.* **$L_1$-$L_3$.** *D. stuposum.*

5b. Leaves many, with distinct sheaths, often covering the internodes.....6
5a. Leaves one to five, without sheaths, clustered at the apex of the stem; stems fusiform to clavate, often quadrangular, sometimes flat (*D. sulcatum*); flowers one to many, mostly on pendant raceme.....*Densiflora*

6a. Stems or pseudobulbs with few internodes near the base swollen and fleshy; the upper part of stem slender; flowers white, lip 3-lobed .....*Rhopalanthe*
6b. Stems uniformly thick, fleshy at middle than at base and apex.....7

7a. Leaves, leafsheaths and stems with deciduous black and brownish hairs; leave apex hairy to sparsely hairy in most of the species; inflorescence racemose with 1 to many flowers towards the growing end; mentum usually long (short in *D. bellatulum*), funnel shaped, straight or incurved.....*Formosae*
7b.No black or brownish hairs on any part of the plant.....8

8a. Plants often tufted, small; stems short with few internodes; inflorescences several, lateral or subterminal, sub-erect to pendant; flowers small, few to many.....*Stachyobium*
8b. Plants often rather large and robust; stems elongate with many internodes; inflorescence lateral; flowers medium to large, solitary or few, sometimes fascicled or many flowered.....9

9a. Flowers with long mentum; inflorescence generated from near the apex .....*Pedilonum*
9b. Flowers usually with a short, saccate mentum.....10

10a. Flowers medium to large, solitary; lip without sidelobes.....*Dendrobium*
10b. Flowers small to medium size; lip with sidelobes.....11

11a. Stems, slender or robust, tall, branching or swollen above the base with leaves towards the apex; infloresence 2-6 flowered from nodes after shedding of leaves.....12
11b. Stems thick with distichous leaves; inflorescence lateral with very short scape, persistent when flowering.....*Distichophyllae*

12a. Apical margin of lip hairy.....*Stuposa*
12b Apical margin of lip not hairy.....*Breviflores*

## Keys to the species

**Section *Aporum***

1a. Stems with long, naked extremities with rudimentary leaves, flowers produced apically or laterally from the nodes of the stems.....2
1b. Stems without naked extremities, usually with equitant leaves throughout, flowers produced on the leafy or leafless stems.....3

2a. Flowers with a dark line along the lateral edge of lip.....*D. spatella*
2b. Flowers without a dark line along the edges of lip.....*D. acinaciforme*

3a. Flowers terminal, 2 or more on a very short peduncle from leafy stems. 4
3b.Flowers solitary, rarely in pairs from the nodes on the leafy or leafless stems.....5

4a. Flowers with long capillary pedicels; lip obovate with a small warty area at the centre.....*D.nathanielis*
4b. Flowers shortly pedicelled; lip with nearly truncate front edge of the fan-shaped blade with a fat median band terminating in swelling triangle at the apex.....*D. terminale*

5a. Lip not bilobulate, only sometimes with a small notch at apex, no incisions separating an epichile and hypochile; flowers produced before the leaves drop off.....*D. anceps*
5b. Epichile of the lip bilobulate with a spilt or v-shaped sinus.....6

6a. Hypochile fan-shaped, apex of epichile with two semilunar or truncate lobules separated by a v-shaped sinus.....7
6b. Hypochile with convex and red edges, epichile through a deep split separated in two often overlapping lobules with fat, close, radiating, somewhat puberulous veins.....*D. keithii*

7a. Flowers produced after the leaves drop off, 12 mm long from the tip of the dorsal sepal to the tip of the mentum.....*D. mannii*
7b. Flowers produce before the leaves drop off, 40 mm long from the tip of the dorsal sepal to the tip of the mentum.....*D. curviflorum*

**Section *Breviflores***

1a. Lip with a fat, pubescent, wall-shaped, transversal callus separating the hypochile from the epichile.....2
1b. No transversal callus on the lip.....3

2a. Transversal wall in lip broad truncate at apex.....*D. aduncum*
2b. Transversal wall on the lip high with a hairy protruding cone somewhat forwards curved at its top.....*D. linguella*

3a. Sepals and petals yellow with maroon to red dots along the veins, mid-vein of lower half of lateral sepals dotted.....*D. dantaniense*
3b. Sepals and petals yellowish green with red dots along the veins, mid-vein of lower half of lateral sepals not dotted .....*D. bicameratum*

**Section *Densiflora***

1a. Pseudobulbs with 2-5 leaves at apical part of stem. Inflorescence pendant.....2
1b. Pseudobulb one leaved.....6

2a. Sepals and petals yellow.....3
2b. Sepals and petals white or light purple. Lip base yellowish.....7

3a. Inforesecence densely many flowered; petal edges finely dentate; upper surface of lip ciliate, with ciliation toward edges more scattered .....*D. densiflorum*
3b. Infloresecence not densely flowered.....4

4a. Stems strongly laterally compressed; petals edges entire; lip concave, papillae mostly along edges.....*D. sulcatum*
4b. Stems not laterally compressed; petals with minutely dentate edges.....5

5a. Stem thickly fusiform with many ridges; inflorescence many flowered, arising from the upper axils of the stem on an erect rachis.....*D. chrysotoxum*
5b. Stem not thickly fusiform, 4-angled; inflorescence sub erect to pendant, few to many flowered.....*D. griffithianum*

6a. Inflorescences many-flowered; upper surface of lip only pubescent at base and centre, leaving a naked brim along edges.....*D. lindleyi*
6b.Inflorescences with one or two flowers; upper surface of lip entirely pubescent.....*D. jenkinsii*

7a. Inflorescence densely many flowered.....*D. thrysiflorum*
7b. Inflorescence not densely flowered.....8

8a. Flowers long lasting; floral bracts concave.....*D. farmeri*
8b. Flowers lasting for a few days; floral bracts small, broad.....*D. palpebrae*

**Section *Dendrobium***

1a. Sepals and petals yellow to copper or coral red.....2
1b. Sepals and petals purple or white with purple tint.....17

2a. Lip strongly branched, fimbriate at edges.....3
2b. Lip edges undulate, entire or erose to finely dentate or ciliate.....6

3a. Fimbriae on lip lax, very long.....*D. brymerianum*
3b. Fimbriae on lip dense, short.....4

4a. Stems fractiflex.....*D. khasianum*
4b. Stem not fractiflex.....5

5a. Lip orbicular, margins evenly fringed along the lateral edge.....
.....*D. fimbriatum*
5b. Lip orbicular, margins deeply fimbriate more towards epichile, fimbriae dense.....*D. hookerianum*

6a. Sepals and petals deep orange to coral red.....*D. dickasonii*
6b. Sepals and petals bright yellow, pale yellow or pale yellowish green.....7

7a. Inflorescence branching.....8
7b. Inflorescence not branching.....9

8a. Lip 20-35 mm long; disc with villous ridges.....*D. ruckeri*
8b. Lip about 15 mm long; disc with glabrous ridges.....*D* × *vexabile*

9a. Flowers pale yellowish green.....*D. macrostachyum*
9b. Flowers not pale yellowish green .....10

10a. Edges of lip forming a pouch.....*D. moschatum*
10b. Lip not pouched.....11

11a. Inflorescence a lax, many flowered raceme .....12
11b. Inflorescence sub-fasciculate,1-to 2-flowered or few flowered racemes
.....14

12a. Floral bracts long (12-15 mm).....13
12b. Floral bracts short (6-9 mm).....*D. gibsonii*

13a. Lip with maroon blotch at the centre of the midlobe.....*D. denneanum*
13b. Lip with an orange blotch at the centre of the midlobe .....*D. chryseum*

14a. Lip longer than sepals and petals.....*D. capillipes*
14b. Lip equally to or slightly larger than sepals and petals.....15

15a. Flowers generated after shedding of leaves.....*D. heterocarpum*
15b. Flowers generated from leaf-bearing plants .....16

16a. Lip with 2 maroon dark blotches at the centre.....*D. chrysanthum*
16b. Lip with a single dark maroon blotch at the centre .....*D. ochreatum*

17a. Stems with swollen nodes or internodes.....18
17b. Stems without swollen nodes or internodes .....22

18a. Stems branching, thin wiry; leaves narrow.....*D. falconeri*
18b. Stems not branching, fleshy; leaves broad.....19

19a. Lip with maroon blotches on either side of the disc .....*D.wardianum*
19b. Lip with yellow blotches on either side of the disc.....20

20a. Column foot with a distinct nectar cavity..... *D. gratiosissimum*
20b. Column foot without a distinct nectar cavity.....21

21a. Petals obtuse with finely erose edges; lip surface pubescent on both sides.....*D. pendulum*
21b. Edges of petals entire; lip upper surface finely pubescent .....*D. findlayanum*

22a. Edges of petals erose, serrulate, or fimbriate .....23
22a. Edges of petals entire .....25

23b. Leaves linear lanceolate, obliquely acutely bifid at apex, distichous .....*D. devonianum*
23b. Leaves ovate-lanceolate to elliptic acute to acuminate or obliquely acutely notched at apex .....24

24a. Lip 3-lobed without a purple blotch at the centre.....*D. assamicum*
24b. Lip not 3-lobed with a purple blotch at the centre.....*D. parishii*

25a. Scape of inflorescence long with up to 10 flowers in a long raceme .....*D. pulchellum*
25b. Scape of inflorescence short with one to few flowers.....26

26a. Inflorescence with a single flower .....*D. polyanthum*
26b. Inflorescence with more than one flower .....27

27a. Petals twisted.....*D.tortile*
27b. Petals not twisted.....28

28a. Flowers with glossy texture.....*D.crepidatum*
28b. Flowers without glossy texture.....29

29a. Lip with one or two maroon, purple or greenish blotches.....30
29a. Lip without blotches.....34

30a. Lip with one or two purple blotches at the centre.....31
30b. Lip with single blotch at the centre.....32

31a. Sepals and petals pure white.....*D. bensoniae*
31b. Sepals and petals white or suffused with pink shade and light purple at the apex and base.....*D. transparens*

32a. Lip with greenish yellow blotch at the centre.....*D. amoenum*
32b. Lip with maroon blotches at the centre.....33

33a. Petals twice as broad as dorsal sepal.....*D. nobile*
33b. Petals not twice as broad as dorsal sepal.....*D. lituiflorum*

34a. Leaves narrowly lanceolate.....*D. moliniforme*
35b. Leaves broadly lanceolate.....35

35a. Operculum with coarse large glossy papillae at apex.....*D. crystallinum*
35b. Operculum minutely papillose.....*D. aphyllum*

**Section *Formosae***

1a. Mentum short, saccate.....*D. bellatulum*
1b. Mentum long, conical, cylindric or funnel-shaped, straight or curved..2

2a. Flowers creamish-yellow, lip with a crimson-white disc and an orange blotch.....3
2b. Flowers milky white.....4

3a. Keels on back of sepals low, hairs on the ridges of disc long .....*D. williamsonii*
3b. Keels on back of sepals high, hairs on the ridges of disc short .....*D. cariniferum*

4a. Stems stout, fusiform or clavate; flowers fairly large, midlobe of lip not fimbriate nor crenulate.....5
4b. Stems slender, fractiflex; flowers medium size, midlobe of lip fimbriate or crenulate.....6

5a. Petals broadly lanceolate acute, unequal, undulate towards apex .....*D. draconis*
5b. Petals suborbicular, broadly elliptic or obovate apiculate.....7

6a. Epichile of lip with an orbicular retuse apex.....*D. formosum*
6b. Epichile of lip with a deep V shaped sinus at the apex ...*D. infundibulum*

7a. Sepals keeled.....8
7b. Sepals not keeled.....*D. wattii*

8a. Leaf apex obliquely acutely bilobed.....*D. longicornu*
8b. Leaf apex obliquely obtusely bilobed.....9

9a. Lip 3-lobed, midlobe fimbriate, fimbriae long and dichotomously branched.....*D. arunachalense*
9b. Lip not 3-lobed, obovate, epichile deeply serrate and not branched .....*D. jaintianum*

**Section *Pedilonum***
1a. Inflorescence corymbose or sub-corymbose.....2
1b. Inflorescences terminal or axillary.....3

2a. Mentum short, column beared.....*D. rhodocentrum*
2b. Mentum longer, column not beared.....*D. cumulatum*

3a. Lip 3-lobed, side lobes erose to toothed.....4
3b. Lip not 3-lobed.....*D. parcum*

4a. Floral bracts, oblong, acuminate at apex.....*D. herbaceum*
4b. Floral bracts ovate, acute at apex.....*D. metrium*

**Section *Stachyobium***
1a. Epichile of lip with long-fimbriate or deeply coarsely fringed edge .....*D. delacourii*
1b. Epichile of lip not with long-fimbriate or fringed edges, but sometimes with wavy edges.....2

2a. Plants small, stems or pseudobulbs ovoid to conical.....3
2b. Stems fusiform tapering towards apex or nearly cylindrical 4 cm long or longer.....5

3a. Plants flowering after shedding of leaves.....*D. peguanum*
3b.Plants leaf-bearing when flowering.....4

4a. Lip with incisions separating the small forwards and upwards pointing triangular tips of sidelobes.....*D. monticola*
4b. No incisions dividing epichile and hypochile.....*D. porphyrochilum*

5a. Lip clawed.....*D. miserum*
5b. Lip not clawed.....6

6a. Dorsal sepal more than 15 mm long.....7
6b. Dorsal sepal less than 12 mm long .....10

7a. Flowers white.....*D. nareshbahadurii*
7b. Flowers not white .....8

8a. Sepals and petals greenish-white.....*D. denudans*
8b. Flowers greenish-yellow, tinged with maroon.....9

9a. Sidelobes rounded, disc with 3 fleshy ridges, the lateral ones longer and thicker than the central one.....*D. numaldeorii*
9b. Sidelobes ovate-triangular; disc with 2 or 3 lamellate ridges, ridges equally thickly and fleshy.....*D. strongylanthum*

10a. Disc with 3-lamellae.....11
10b. Disc not with 3-lamellae.....12

11a. Lateral lobes dentate at the apex.....*D. sinominutiflorum*
11b. Lateral lobes not dentate at the apex.....*D. darjeelingense*

12b. Edges of hypochile of lip strongly inciso-serrate.....*D. eriiflorum*
12b. Edges of hypochile of lip entire or minutely crenulate.....
.....*D. pycnostachyum*

**Section *Stuposa***

1a. Sepals and petals pure white; midlobe apical margin densely long ciliate-hairy.....*D. stuposum*
1b. Sepals and petals yellowish white with dark purple edges; midlobe apical margin thinly short ciliate-hairy.....*D. praecinctum*

**Section *Strongyle***

1a. Flowers 30 mm long; lip obovate, apex of epichile bilobed .....*D. kentrophyllum*
1b Flowers 20 mm long; lip obovate-truncate, apex of epichile retuse .....*D.parciflorum*

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# Appendix 1
# Main morphological differences between *Dendrobium, Epigeneium* and *Flickingeria*

| *Dendrobium* | *Epigeneium* | *Flickingeria* |
|---|---|---|
| Pseudobulbs or stems erect, 1 to several nodes from base of old ones, tough and fleshy, swollen at base or along whole length, often covered with sheathing leaf bases and bladeless sheaths. | Pseudobulbs erect, ovoid, enclosed in sheaths. | Stems erect, several nodes, apical node swollen, sheathed (when young), branched from upper nodes to form elongate, superposed erect or pendent clumps. |
| Leaves 1 to many, apical from pseudobulb or arranged distichously along stem. | Leaves 1 or 2, arising from pseudobulb apex, oblong to obovate. | Leaf single, apical, narrowly elliptic to oblong-elliptic |
| Inflorescence a raceme 1- to many-flowered, erect, horizontal or pendent, lateral or terminal. | Inflorescence a raceme 1- to several-flowered, terminal from pseudobulb. | Inflorescences 1-flowered, subterminal, borne in front or behind leaf base. |
| Flowers small, medium to large in size, often showy, long-lived. | Flowers medium to large in size, often showy, long-lived. | Flowers small to medium in size, ephemeral, thinly membranous. |
| Mentum spur like, conical, saccate, and rounded. | Mentum rounded. | Mentum chin-like. |
| Lip simple to 3-lobed, pubescent or not. Disc 1- to 7-keeled, usually ecallose. | Lip 3-lobed, not pubescent, pandurate-oblong. Disc with a lobulate or ridged callus on basal part, with 2 longitudinal lamellae. | Lip 3-lobed, not pubescent. Callus on basal part of 2 or 3 raised longitiudinal lamellae. |

1: Botanical Survey of India, Eastern Regional Centre, Shillong-793003, Meghalaya, India
drchayadeoribsi@gmail.com